iNEST – Interconnected Nord-Est Innovation Ecosystem: General Frame of the Project and Activities of Young Researchers at the University of Trieste

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A comprehensive database on contaminants as decision-support tool for local authorities in environmental management of coastal-marine sediments in the Northern Adriatic

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↦ ABSTRACT

In line with the objectives of European Commission (2017) for achieving a good environmental status, this study supports sustainable development by creating a tool for assessing the environmental quality and risks connected to the presence of contaminants in coastal-marine environments. Focusing on the Northern Adriatic Sea, the research aims to establish a reference framework for the spatial distribution of both organic and inorganic contaminants by collecting and evaluating historical data of sediments as they act as a long-term sink for contaminants of both natural and anthropogenic origin. The final output of this study will encompass both a comprehensive documentation of available data and the development of a decision-support tool for regional authorities involved in the management and protection of the coastal-marine environment, specifically tailored to the unique conditions of the Northern Adriatic where aquatic ecosystems of high natural value coexist with economic/productive (fishing and fish farming), environmental (ecosystem status and quality objectives) and social interests (recreational/maritime tourism activities) for local inhabitants.

INTRODUCTION

The research activity is structured into three distinct phases, as follows:

1. Critical analysis of the scientific literature, acquisition and organisation of the available data;
2. Data processing and geochemical mapping of the sediment characteristics and concentrations of contaminants;
3. Development of predictive empirical models and decision-support tools.

A bibliographic search (sources: Scopus, Web of Science, institutional archives) was conducted on existing data relating to coastal-marine sediments in the Northern Adriatic Sea with specific reference on the occurrence of potentially toxic trace elements such as arsenic (As), cadmium (Cd), copper (Cu), chromium (Cr), mercury (Hg), nickel (Ni), lead (Pb) and zinc (Zn). In addition, other parameters such as grain size distribution, nutrients and major elements (e.g., Al, C_{org}, C_{tot}, N_{org}, N_{tot}, Fe, P), and other organic contaminants (PAHs, PCBs, organochlorine pesticides, organotin compounds) were also evaluated.

DATABASE MANAGEMENT

The data from the literature review were collected and organized in a database in order to make all existing data available in digital format. The database, created in MS Excel® and therefore easily accessible, was organized into four sections: "*Data*", "*Sources*", "*Methods*" and "*Bibliography*" (Fig. 1).

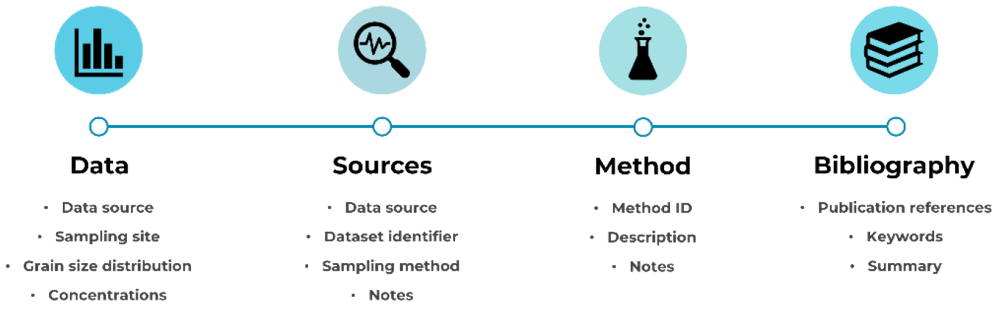

Figure 1
Database organization into four sections and related subsections

The "*Data*" sheet contains analytical data on metals and organic contaminants, accompanied by geographical and grain-size information (where available). The sheet is divided into four subsections. The "Data source" section shows the source of the data, including the dataset identifier and the original name of the sampling station or sample. The "Sampling site" section includes the date of the sampling, the geographical coordinates and depth of the sampling location, the substrate type and the sample level in the case of sediment cores. The "Grain size distribution" section provides the grain size values as the relative frequency of each Φ (phi) class available in the original work. The "Concentrations" section reports the value of concentration of the different analytes, with the relative unit and an indication of the method used for the determination. In addition, information is also provided on the date of the analysis and the reliability of the data, rated on a scale from 1 to 5, based on the information reported in the original data source about sampling, storage methods and the analytical methodology applied.

The "*Sources*" sheet provides a summary list of the consulted sources, identified by the authors of the study and the year of publication, together with a unique identifier (name) of the dataset. This section briefly describes the sampling methods and the equipment used. Marginal notes have been added with details concerning the origin of the data, which are useful for assessing its reliability (purpose of the study, missing or unreported data, etc.).

The "*Method*" sheet contains a list of analytical methods, identified by a sequential code (M1, M2, M3, etc.), used in each study to determine the various contaminants present in the different sources examined. A description of each method is provided, together with any references to official methods such as those published by EPA, UNI, CNR-IRSA, etc. The "notes" section describes the equipment used and provides information on sample preparation.

The "*Bibliography*" sheet contains the complete bibliographic references to the consulted datasets and to the product in which they are reported (scientific papers, thesis, technical reports), together with a brief summary and keywords of these publications.

Currently, a total of 3020 individual sediment samples are stored in the database (Fig. 2), of which 1896 are surface sediment samples and 1114 single sediment core levels.

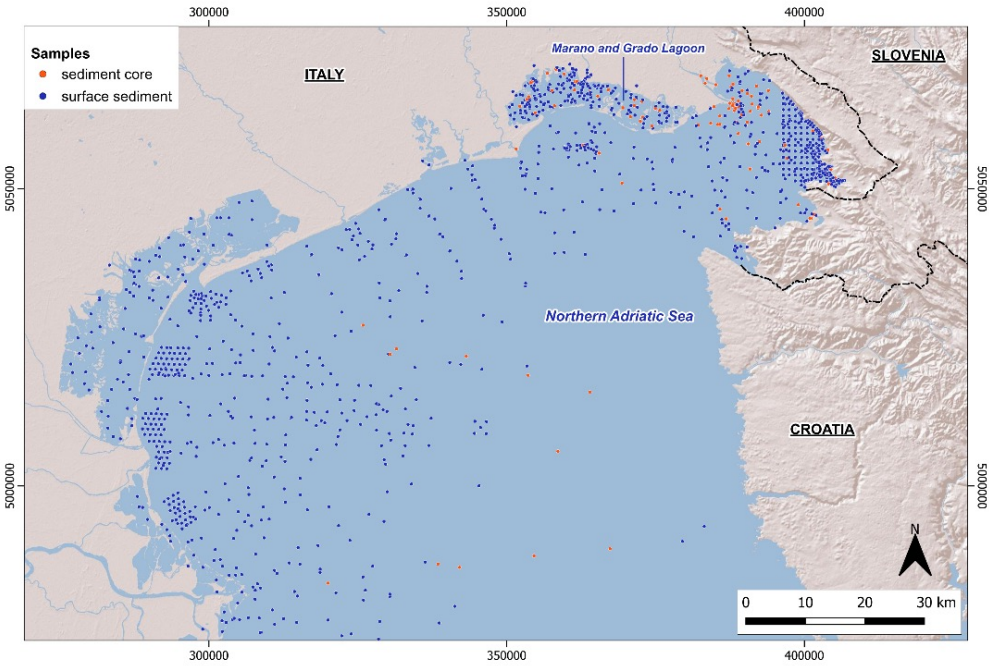

Figure 2
Spatial distribution of available data on sediments in the Northern Adriatic Sea

⇨ DATA ELABORATION: THE CASE STUDY OF THE MARANO AND GRADO LAGOON

As a potential tool for sediment characterisation and management, a geochemical data analysis approach, together with a geostatistical elaboration, was tested on a selected sub-area, the Marano and Grado Lagoon, to determine local background values, in order to test and develop an empirical model to be applied to the coastal-marine area. The estimation of background concentrations is essential for assessing anthropogenic contributions, evaluating the extent of contamination both historically, using sediment cores, and regionally, through surface sediments, as well as for fulfilling national and regional regulatory requirements. Among the methods used for background estimation, the use of potentially

toxic element (PTE) concentrations obtained from deep sections of sediment cores, corresponding to the pre-industrial period, has been recognised as the most useful and common strategy. As a part of this geochemical procedure, the natural variability of the geochemical parameters must be taken into account, especially the grain-size, since trace elements are naturally concentrated in the finest component (silt and clay) of sediments (Covelli et al., 2025; Covelli and Fontolan, 1997; Lipizer et al., 2022). In this regard, PTE concentrations must be normalised using a grain-size proxy, namely a conservative element derived from crustal rocks that is minimally affected by human activities; aluminium (Al) is the most commonly used normalizing element as it is one of the most abundant elements on Earth and is generally not considered to be of anthropogenic origin. Linear functions, which represent the mathematical relationships ($y = ax + b$) between the normalising element (on the x-axis) and a given major or trace element (on the y-axis), are actually regional geochemical baseline functions (GBFs). The theoretical concentration, which corresponds only to the lithogenic contribution to the concentration of a given element (y), may be calculated on the basis of the real concentration of the normalising element (x), i.e., determined analytically in the sample under investigation. These linear relationships are used to determine whether there is an enrichment of PTEs in the sediments in the area under investigation. For each element, an Enrichment Factor (EF) is then calculated as the ratio of the analytically determined concentration and the theoretical concentration, calculated using the regional GBF. An EF of 1 denotes no enrichment or depletion compared to the natural background, whereas an EF greater than 1.5 indicates that a significant proportion of the PTE comes from non-natural sedimentary materials, such as sources of contamination.

This approach allows regional geochemical functions and enrichment factor to be calculated for each potential toxic element, in order to assess the degree of contamination related to local background values and to identify potential sources of contamination. Local geochemical functions can be used to create predictive empirical models that provide an estimate of expected concentrations based on effective predictive variables, providing useful tool for properly assessing environmental risks associated with sediment management, particularly in the context of maintenance dredging.

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